DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

Technical Report 1691-TR

THE SM-1 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM

NOVEMBER 1954 - DECEMBER 1960

31 August 1961

U. S. Army Engineer Research And Development Laboratories

FORT BELVOIR, VIRGINIA

AD ______________ Accession No. ______________

U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia - THE SM-1 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM, NOVEMBER 1954 - DECEMBER 1960 - Maurice Pressman and Paul B. Pruett

Report 1691-TR, 31 Aug 61, 36 pp, 17 tables, 18 illus
Unclassified Report

This report covers an environmental radiological monitoring program which is being conducted for the Nuclear Power Field Office by the Sanitary Sciences Branch, USAERDL. A summary of the data previously presented in a series of sixteen detailed internal progress reports covering the period from November 1954 through December 1960 is given in this report. The following samples were assayed for radioactivity: River water and bottom silt; SM-1 condenser cooling water; subsurface ground water; rain and snow; atmospheric particles obtained by air filtration and fallout; and biota. The report concludes that after more than 3 years of SM-1 reactor operation, no significant increase has been noted in the radiological background level in the Fort Belvoir area.

UNCLASSIFIED
Contract - None.

AD ______________ Accession No. ______________

U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia - THE SM-1 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM, NOVEMBER 1954 - DECEMBER 1960 - Maurice Pressman and Paul B. Pruett

Report 1691-TR, 31 Aug 61, 36 pp, 17 tables, 18 illus
Unclassified Report

This report covers an environmental radiological monitoring program which is being conducted for the Nuclear Power Field Office by the Sanitary Sciences Branch, USAERDL. A summary of the data previously presented in a series of sixteen detailed internal progress reports covering the period from November 1954 through December 1960 is given in this report. The following samples were assayed for radioactivity: River water and bottom silt; SM-1 condenser cooling water; subsurface ground water; rain and snow; atmospheric particles obtained by air filtration and fallout; and biota. The report concludes that after more than 3 years of SM-1 reactor operation, no significant increase has been noted in the radiological background level in the Fort Belvoir area.

UNCLASSIFIED
Contract - None.

AD ______________ Accession No. ______________

U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia - THE SM-1 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM, NOVEMBER 1954 - DECEMBER 1960 - Maurice Pressman and Paul B. Pruett

Report 1691-TR, 31 Aug 61, 36 pp, 17 tables, 18 illus
Unclassified Report

This report covers an environmental radiological monitoring program which is being conducted for the Nuclear Power Field Office by the Sanitary Sciences Branch, USAERDL. A summary of the data previously presented in a series of sixteen detailed internal progress reports covering the period from November 1954 through December 1960 is given in this report. The following samples were assayed for radioactivity: River water and bottom silt; SM-1 condenser cooling water; subsurface ground water; rain and snow; atmospheric particles obtained by air filtration and fallout; and biota. The report concludes that after more than 3 years of SM-1 reactor operation, no significant increase has been noted in the radiological background level in the Fort Belvoir area.

UNCLASSIFIED
Contract - None.

AD ______________ Accession No. ______________

U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia - THE SM-1 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM, NOVEMBER 1954 - DECEMBER 1960 - Maurice Pressman and Paul B. Pruett

Report 1691-TR, 31 Aug 61, 36 pp, 17 tables, 18 illus
Unclassified Report

This report covers an environmental radiological monitoring program which is being conducted for the Nuclear Power Field Office by the Sanitary Sciences Branch, USAERDL. A summary of the data previously presented in a series of sixteen detailed internal progress reports covering the period from November 1954 through December 1960 is given in this report. The following samples were assayed for radioactivity: River water and bottom silt; SM-1 condenser cooling water; subsurface ground water; rain and snow; atmospheric particles obtained by air filtration and fallout; and biota. The report concludes that after more than 3 years of SM-1 reactor operation, no significant increase has been noted in the radiological background level in the Fort Belvoir area.

UNCLASSIFIED
Contract - None.

AD ______ Accession No. ______

U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia - THE SM-1 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM, NOVEMBER 1954 - DECEMBER 1960 - Maurice Pressman and Paul B. Pruett

Report 1691-TR, 31 Aug 61, 36 pp, 17 tables, 18 illus
Unclassified Report

This report covers an environmental radiological monitoring program which is being conducted for the Nuclear Power Field Office by the Sanitary Sciences Branch, USAERDL. A summary of the data previously presented in a series of sixteen detailed internal progress reports covering the period from November 1954 through December 1960 is given in this report. The following samples were assayed for radioactivity: River water and bottom silt; SM-1 condenser cooling water; subsurface ground water; rain and snow; atmospheric particles obtained by air filtration and fallout; and biota. The report concludes that after more than 3 years of SM-1 reactor operation, no significant increase has been noted in the radiological background level in the Fort Belvoir area.

UNCLASSIFIED
Contract - None.

AD ______ Accession No. ______

U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia - THE SM-1 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM, NOVEMBER 1954 - DECEMBER 1960 - Maurice Pressman and Paul B. Pruett

Report 1691-TR, 31 Aug 61, 36 pp, 17 tables, 18 illus
Unclassified Report

This report covers an environmental radiological monitoring program which is being conducted for the Nuclear Power Field Office by the Sanitary Sciences Branch, USAERDL. A summary of the data previously presented in a series of sixteen detailed internal progress reports covering the period from November 1954 through December 1960 is given in this report. The following samples were assayed for radioactivity: River water and bottom silt; SM-1 condenser cooling water; subsurface ground water; rain and snow; atmospheric particles obtained by air filtration and fallout; and biota. The report concludes that after more than 3 years of SM-1 reactor operation, no significant increase has been noted in the radiological background level in the Fort Belvoir area.

UNCLASSIFIED
Contract - None.

AD ______ Accession No. ______

U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia - THE SM-1 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM, NOVEMBER 1954 - DECEMBER 1960 - Maurice Pressman and Paul B. Pruett

Report 1691-TR, 31 Aug 61, 36 pp, 17 tables, 18 illus
Unclassified Report

This report covers an environmental radiological monitoring program which is being conducted for the Nuclear Power Field Office by the Sanitary Sciences Branch, USAERDL. A summary of the data previously presented in a series of sixteen detailed internal progress reports covering the period from November 1954 through December 1960 is given in this report. The following samples were assayed for radioactivity: River water and bottom silt; SM-1 condenser cooling water; subsurface ground water; rain and snow; atmospheric particles obtained by air filtration and fallout; and biota. The report concludes that after more than 3 years of SM-1 reactor operation, no significant increase has been noted in the radiological background level in the Fort Belvoir area.

UNCLASSIFIED
Contract - None.

AD ______ Accession No. ______

U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia - THE SM-1 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM, NOVEMBER 1954 - DECEMBER 1960 - Maurice Pressman and Paul B. Pruett

Report 1691-TR, 31 Aug 61, 36 pp, 17 tables, 18 illus
Unclassified Report

This report covers an environmental radiological monitoring program which is being conducted for the Nuclear Power Field Office by the Sanitary Sciences Branch, USAERDL. A summary of the data previously presented in a series of sixteen detailed internal progress reports covering the period from November 1954 through December 1960 is given in this report. The following samples were assayed for radioactivity: River water and bottom silt; SM-1 condenser cooling water; subsurface ground water; rain and snow; atmospheric particles obtained by air filtration and fallout; and biota. The report concludes that after more than 3 years of SM-1 reactor operation, no significant increase has been noted in the radiological background level in the Fort Belvoir area.

UNCLASSIFIED
Contract - None.

U. S. ARMY ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES
CORPS OF ENGINEERS

Technical Report 1691-TR

THE SM-1 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM

NOVEMBER 1954 - DECEMBER 1960

31 August 1961

Distributed by

The Director
U. S. Army Engineer Research and Development Laboratories
Corps of Engineers

Prepared by

Maurice Pressman
and
Paul B. Pruett
Sanitary Sciences Branch
Military Department
U. S. Army Engineer Research and Development Laboratories
Corps of Engineers
Fort Belvoir, Virginia

If there is no requirement for this report,
return it to:

Commanding General
U. S. Army Engineer Research and Development Laboratories
Fort Belvoir, Virginia

PREFACE

The investigation covered in this report was conducted under the authority of a series of special work orders from the Nuclear Power Field Office to the Sanitary Sciences Branch, U. S. Army Engineer Research and Development Laboratories (USAERDL).

The period covered by this report is from November 1954 through December 1960.

The following personnel supervised the program: Don C. Lindsten, Chief, Research Section; Richard P. Schmitt, Chief, Sanitary Sciences Branch; and Neil K. Dickinson, Chief, Military Department.

The collecting and processing of samples was done by civilian and military personnel assigned to the Sanitary Sciences Branch.

Acknowledgment is made of the cooperation extended by the personnel of the Nuclear Power Field Office during all phases of the program.

CONTENTS

SUMMARY

An environmental radiological monitoring program, in connection with the operation of the first United States Army package power reactor (SM-1), is being conducted for the Nuclear Power Field Office by the Sanitary Sciences Branch, USAERDL. The report compiles and summarizes all data obtained during a period extending from 1½ years prior to SM-1 reactor start-up through more than 3 years of reactor operation. The period extended from November 1954 through December 1960.

Samples assayed for radioactivity include the following: River water and bottom silt; SM-1 condenser cooling water; subsurface ground water; rain and snow; atmospheric particles obtained by air filtration and fallout; and biota.

The report concludes that after more than 3 years of SM-1 reactor operation, no significant increase has been noted in the radiological background level in the Fort Belvoir area.

TABLES

ILLUSTRATIONS

THE SM-1 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM

NOVEMBER 1954 - DECEMBER 1960

I. INTRODUCTION

1. Subject. This report presents a summary of all the data that have been obtained from November 1954 through December 1960 in the environmental radiological monitoring program conducted at Fort Belvoir, Virginia, in connection with the operation of the first United States Army package power reactor (SM-1).

2. Background. In man's environment today, two distinct sources of radioactivity exist: Natural background activity, and activity related to man-made radionuclides. Natural-occurring thorium and uranium are radioactive and are parent members of radioactive series which yield some thirty-five radioactive daughter products such as radium and radon. In addition, other radioisotopes such as potassium-40 and carbon-14 exist in nature. Cosmic radiation also contributes to the natural background. Prior to the first nuclear detonation in 1945, this background at any particular location on the earth's surface was essentially constant. With the advent of the era of nuclear weapons, the development of the nuclear power industry, and the increased use of radioisotopes in research laboratories, universities, and hospitals, environmental radioactivity at a particular location has been subject to wide fluctuations.

With the development of the nuclear power program, the fission product wastes from nuclear reactors represent one of the greatest potential sources of radioactive contamination in the environment. At the end of 1960, a listing of heat-producing reactors--past, present, and being constructed--totaled well over 100. Discharge of radioactive wastes from these reactors is closely controlled by governmental agencies in those countries where a nuclear power program exists.

In the United States, the development of the nuclear power program is controlled by the Atomic Energy Commission (AEC). One of the requirements of the Commission relating to power reactor plants is the conducting of an environmental radiological monitoring program at each reactor site. Each plant is equipped with internal monitoring instruments the function of which is to detect significant contaminating events such as fuel element ruptures, leaks, and spills. The purpose of the external monitoring program is to determine whether the activities of the reactor plant are contributing significant radioactive contamination to the environment surrounding the plant. A knowledge of the background radiation level at any location before the establishment of a power reactor plant is, of

course, essential to the evaluation of data obtained subsequent to plant startup so that any immediate changes or gradual changes in the background can be detected.

To set up an environmental monitoring program in connection with a reactor operation, local considerations must be given to the location of watercourses, centers of population, and the direction of prevailing winds. These considerations mainly determine the type and number of samples taken, the sampling frequency, and the sampling station locations. The sampling program must be designed to give an accurate appraisal of the environmental radioactivity without an excess number of samples.

Samples which are valuable in indicating radioactive contamination are river water and bottom silt above and below the plant, condenser cooling water at the intake and outlet of the reactor plant, subsurface ground water close to the plant, rain or snow, atmospheric particles obtained by air filtration and fallout, and biota. Each type of sample has its own particular significance. For example, a river water sample can yield data as to the radioactivity content of the flowing water, in both dissolved and suspended form, at the particular time of collection. The normal gross radioactivity of surface water is in the order of 10^{-10} to 10^{-8} microcuries per cubic centimeter ($\mu c/cc$). A comparison of this range of values with the maximum permissible concentration (MPC) value of 10^{-7} $\mu c/cc$ for drinking water consumption (Handbook 69, National Bureau of Standards) for unknown alpha and beta emitters emphasizes the need for collection of specific background data and continuous monitoring of any stream receiving discharge from a reactor plant. A biota sample such as algae or fish or a river bottom sediment sample may represent a cumulative condition in a stream. It is well known that algae can concentrate radioisotopes to many hundreds of times the amount in the surrounding water. Algae are consumed by zooplankton and bottom animals which, in turn, are consumed by fish used as food by man. Some fish may feed directly on algae. The eventual human consumption of radioisotopes concentrated in aquatic animals in the natural food chain points up the significance of a biota study as part of a monitoring program. Results obtained from samples of fallout on gummed paper, rain or snow, and air filtration particles, are indicative of the particulate radioactivity in the atmosphere. The levels of radioactivity in both air and precipitation may be exceedingly variable and, in the absence of unusual contaminating events in the locality, reflect contamination from distant nuclear device detonations rather than reactor plant operation.

The variations of the day-by-day results of any continuous monitoring program must be evaluated in the light of these occurrences which might be taking place at a location far from the reactor

plant. The effect which a single contaminating event anywhere in the world can have on the environment at any location is shown in Fig. 1. Between the end of October 1958 and February 1960, no surface detonations of nuclear devices had been reported by any of the world powers. The constant, low fallout activity at the two Fort Belvoir gummed paper stations during the latter part of 1959 reflected the results of this moratorium. On 13 February 1960, the French Government announced a surface nuclear detonation in North Africa. The sudden rise in activity of the gummed paper removed on 23 February 1960, after 1 week of exposure, demonstrated the effect on the environment of a single contaminating event taking place thousands of miles away from a reactor site.

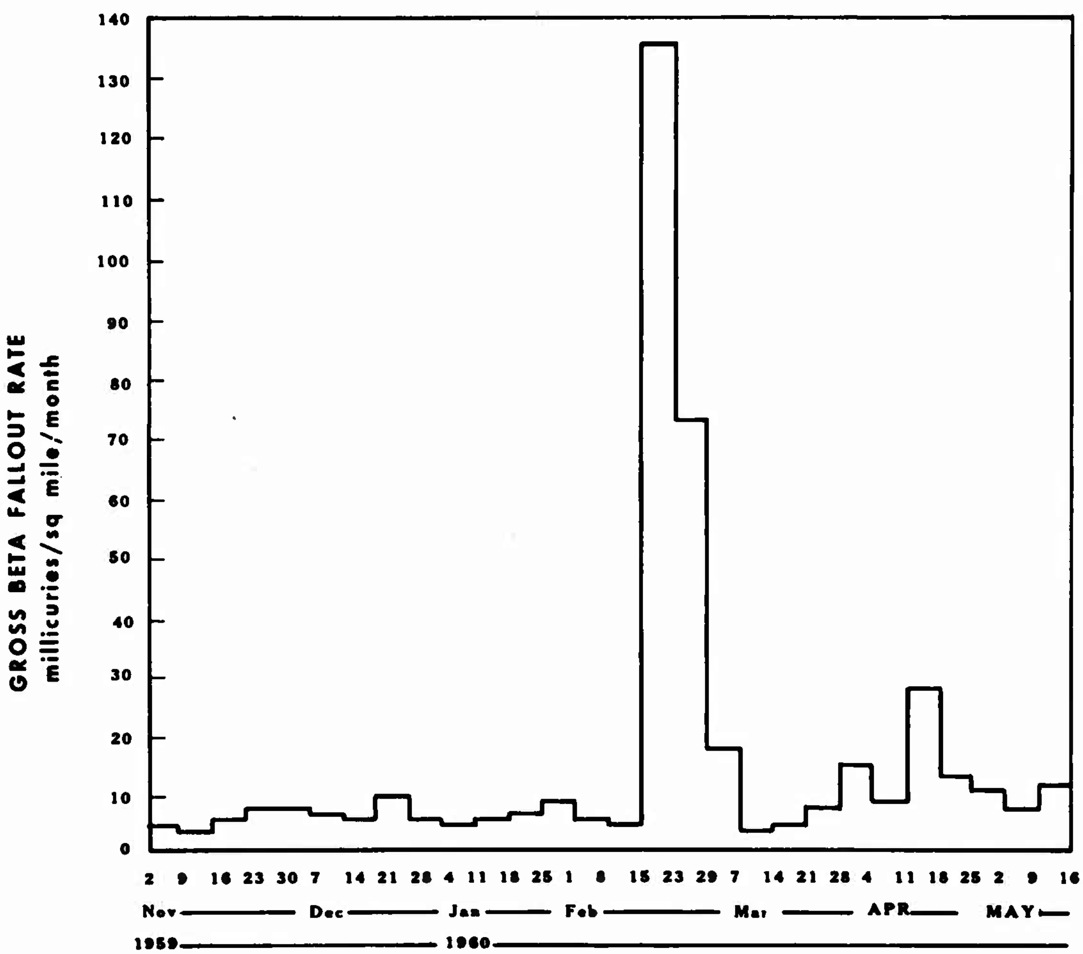


Fig. 1. Effect of French nuclear detonation, 13 February 1960, on beta fallout rate at Davison Field gummed paper station.

3. History of the SM-1 Environmental Radiological Monitoring Program. The first United States Army package power reactor (APPR-1), now designated as SM-1 (Fig. 2), was set in operation at Fort Belvoir, Virginia, in April 1957. The environmental monitoring program currently being conducted by the Sanitary Sciences Branch, U. S. Army Engineer Research and Development Laboratories (USAERDL), was initiated in November 1955; thus, 18 months of background data had been accumulated before the start of reactor operation. Prior to this time, irregular environmental sampling was conducted in connection with a project to investigate decontamination of water containing chemical, biological, and radiological agents.

Initially water samples were taken from eight Potomac River stations, a ground water well near the reactor site, all rainfall and snowfall at Fort Belvoir, and from gummed paper set up at nine stations to gather particulate fallout. In addition, bottom sediment samples were taken every 3 months at ten locations in the Potomac River and Accotink Bay. The area covered by the SM-1 environmental radiological monitoring program is shown in Fig. 3. Two gummed paper station locations are not shown, namely, one at the Alexandria Masonic Memorial, about 12 miles northeast of Fort Belvoir, and the other at the Dalecarlia Water Plant, in northwest Washington, D. C.

From time to time changes were made in the number and type of samples taken as well as in the sampling frequencies. Figure 4 shows sampling periods and locations of samples taken, from the initial sampling time in November 1954 until the end of December 1960.

At the end of 1960, the following sampling schedule was being observed.

a. SM-1 Cooling Water at Inlet. A 1-liter sample was collected on Monday, Tuesday, Thursday, and Friday from the SM-1 intake structure pier.

b. SM-1 Cooling Water at Outlet. A 1-liter sample was collected on Monday, Tuesday, Thursday, and Friday at the SM-1 condenser cooling water outfall.

c. Precipitation. Samples were collected by an automatic sampling device on the roof of Building 325, USAERDL, as rain or snow occurred.

d. Fallout on Gummed Paper. Four exposure stations were established at the SM-1 site, and one at Davison Field. Usually 1-foot-square samples were exposed at the stations for a period of 1 week; however, during periods of increasing radioactive count samples were collected daily from these stations.

18297

Fig. 2. First United States Army package power reactor plant (SM-1) at Fort Belvoir, Virginia.

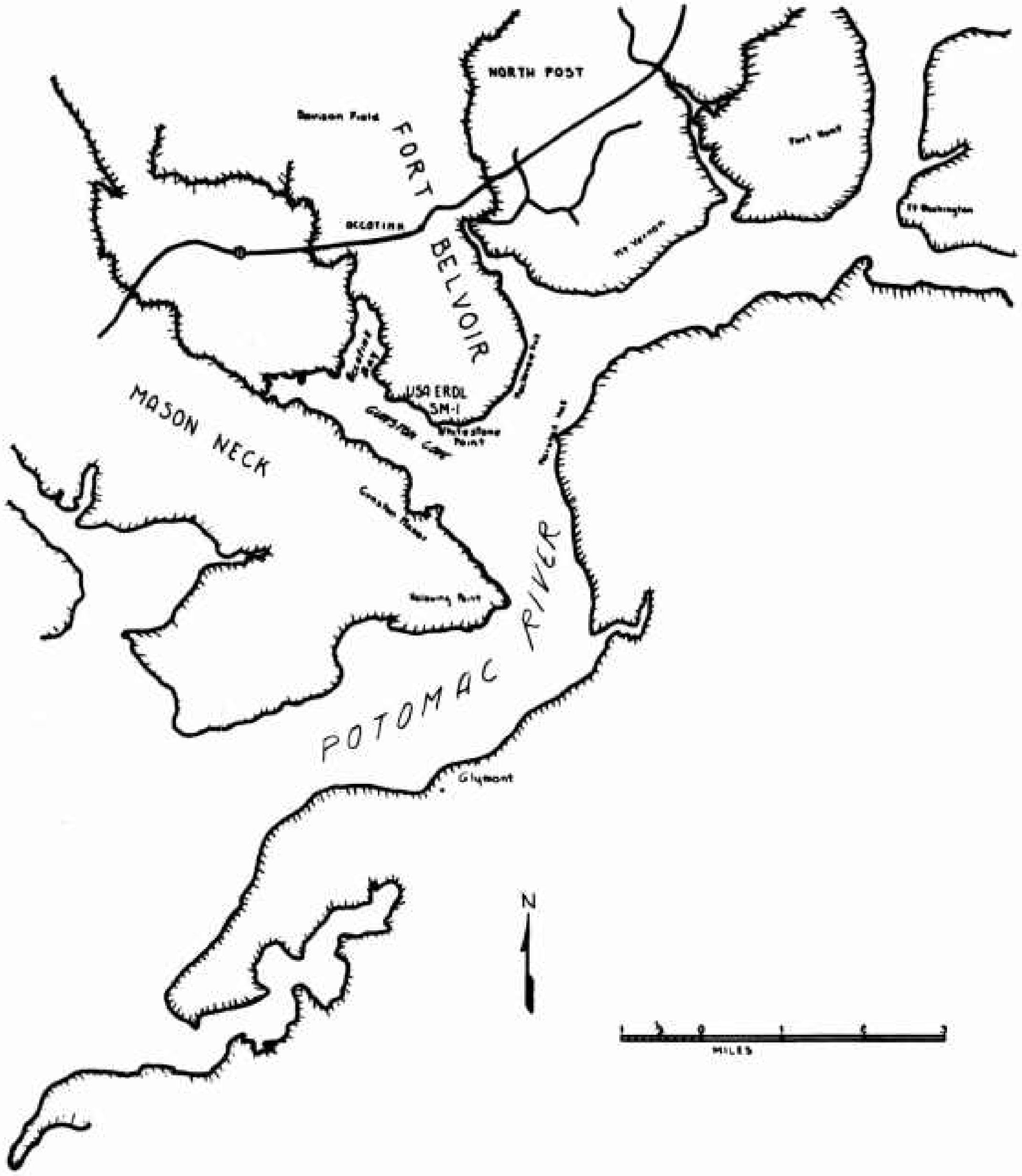


Fig. 3. Map showing area covered by SM-1 environmental radiological monitoring program.

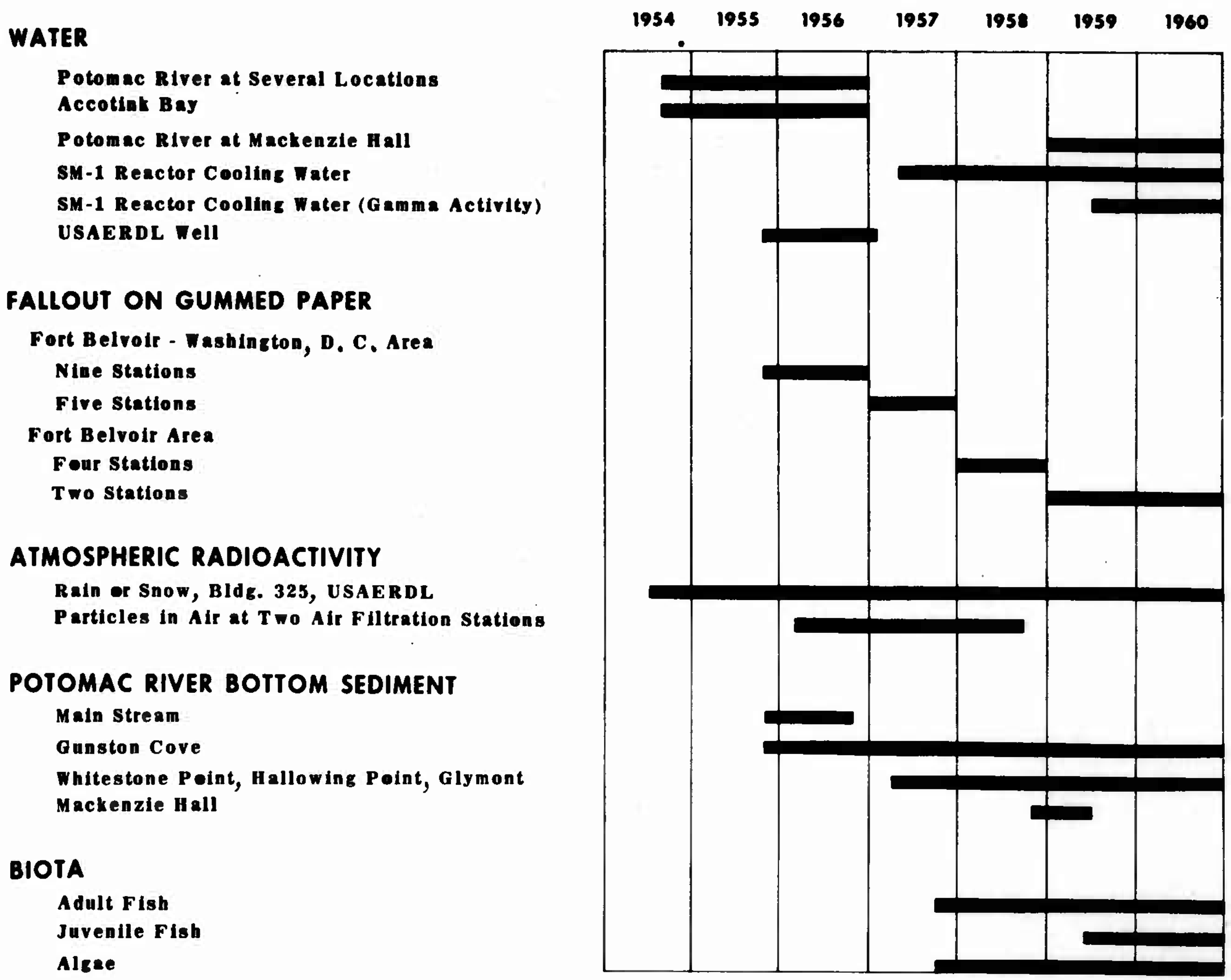


Fig. 4. Annual sampling schedule for SM-1 environmental radiological monitoring program.

e. Potomac River Water. One-liter samples were collected every Tuesday from the pier near Mackenzie Hall.

f. Gunston Cove Sediment and Water. Samples of bottom sediment and water were collected once during a 4-month period at three locations close to the point where the SM-1 cooling water stream enters Gunston Cove.

g. Potomac River Sediment and Water. Samples of bottom sediment and water were collected once during a 4-month period at three locations: Whitestone Point, Hallowing Point, and Glymont.

h. Potomac River Water for Gamma Count. Five-gallon samples were taken in precounted polyethylene bottles every fourth Tuesday at the SM-1 cooling water intake and outfall at the same locations as were mentioned in paragraphs a and b in the sampling schedule. The two samples were counted the following day at Walter Reed Army Institute of Research, Washington, D. C., in the whole body gamma counter.

i. Biota. For each survey, conducted once during a 4-month period, samples taken in Gunston Cove consisted of ten adult fish, ten juvenile fish, and ten algae. In addition, ten algae samples were collected from the shore near Mackenzie Hall.

On 4 May 1960, an aerial survey for gamma activity over the SM-1 reactor plant and at various locations in the vicinity of Fort Belvoir was conducted in cooperation with the United States Geological Survey. A specially equipped airplane carrying a bank of gamma scintillation counters and Esterline-Angus recorders was used. When the airplane was flying at an altitude of 250 feet, the total gamma activity recorded over Mount Vernon was 620 counts per second. When the airplane was at the same altitude directly over the SM-1 reactor plant, the total gamma activity was 10,400 counts per second. Representative aeroradioactivity data obtained during this survey are shown in Table I.

II. INVESTIGATION

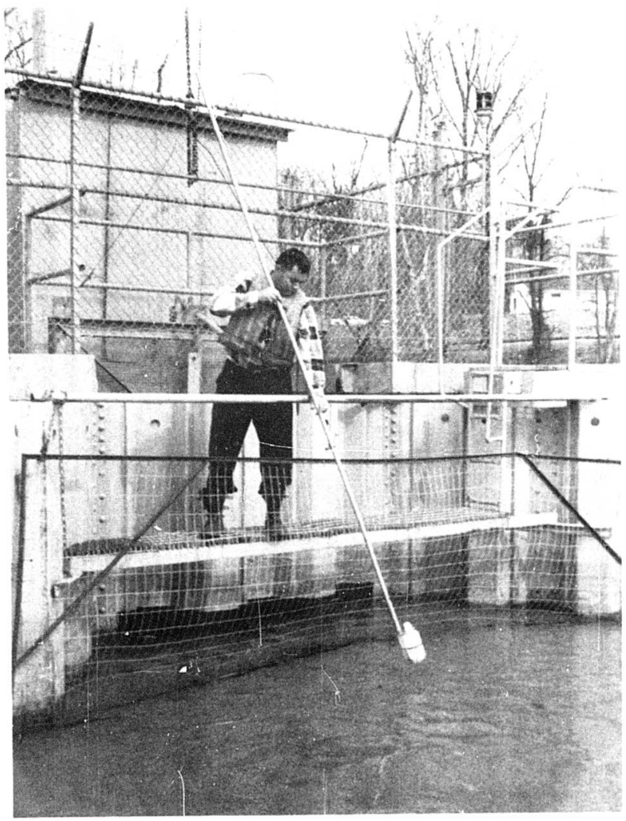
4. Procedures. When the monitoring program was established in 1955, the sampling procedures and analytical techniques were patterned after procedures used by the Atomic Energy Commission and those in use at the Oak Ridge National Laboratory where the Sanitary Sciences Branch maintained a test station. Although the number and types of samples have been altered through the years, the procedures described here have remained essentially unchanged from those originally set up.

Table I. Aerial Survey for Gamma Radioactivity in the Fort Belvoir Area, 4 May 1960

Location	Altitude (ft)	Total Gamma Activity (counts per second)
Mount Vernon	250	620
	500	500
	750	400
Accotink	250	600
	500	440
	750	400
SM-1 Reactor Plant	250	10,400
	500	780
	750	500

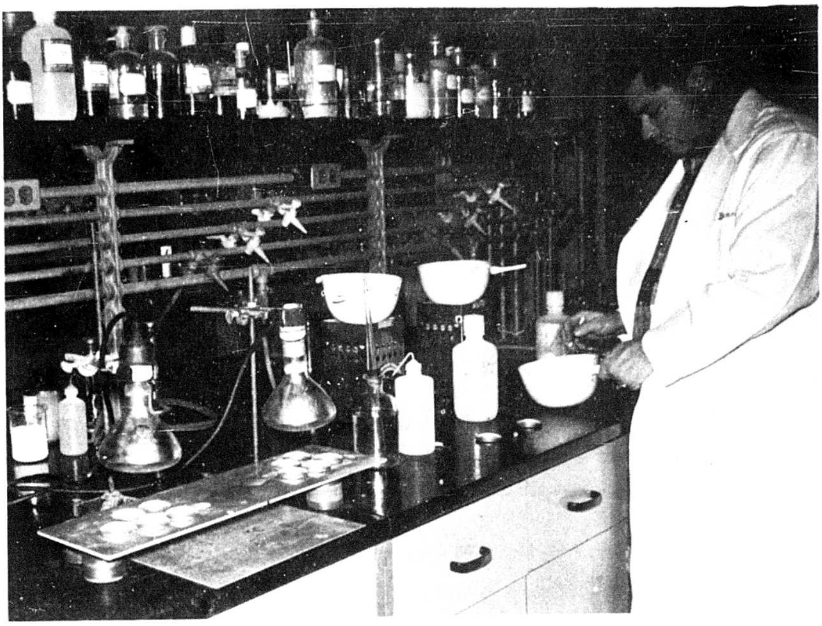
Water samples were taken in a 1-liter polyethylene bottle mounted on the end of a sectionalized aluminum pole. Figure 5 shows a sample being taken from the Potomac River at the SM-1 condenser cooling water intake. Figure 6 shows a sample being taken of SM-1 condenser cooling water as it discharges to Gunston Cove. The sample was evaporated to near dryness in a casserole and the residue was transferred to a counting planchet with the aid of a rubber policeman and a little dilute acid. The residue was then dried under an infrared lamp and counted in an end window beta counter standardized with Tl^{204}. Figure 7 shows some of the equipment used in the analytical procedures. Figure 8 is a view of the counting room at the Sanitary Sciences Branch.

Rain and snow samples were collected in an automatic sampling device mounted on the roof of Building 325, USAERDL (Fig. 9). This device was designed and fabricated by the Sanitary Sciences Branch. The cover over the funnel remains closed until rain or snow wets a sensing device on the outside of the box and activates the cover-lifting mechanism. When the precipitation stops, heat from an electric bulb which burns during the period that the cover is open, dries the sensing unit and the cover closes. By having the funnel exposed only when precipitation occurs, the activity of the sample represents only activity associated with the precipitation, and not accumulated fallout which might also be washed in from an exposed funnel. The device replaced an uncovered funnel used prior to July 1959 (Fig. 10). The procedure for processing samples of precipitation was the same as that described in the preceding paragraph.



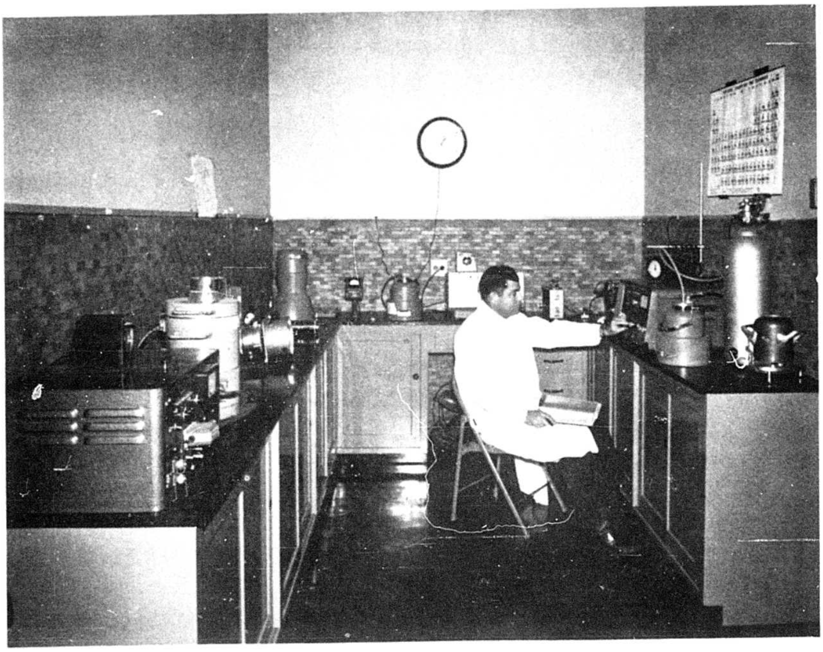
H2817
Fig. 5. Sampling Potomac River water at SM-1 condenser cooling water intake.

H2818
Fig. 6. Sampling SM-1 condenser cooling water as it discharges to Gunston Cove.



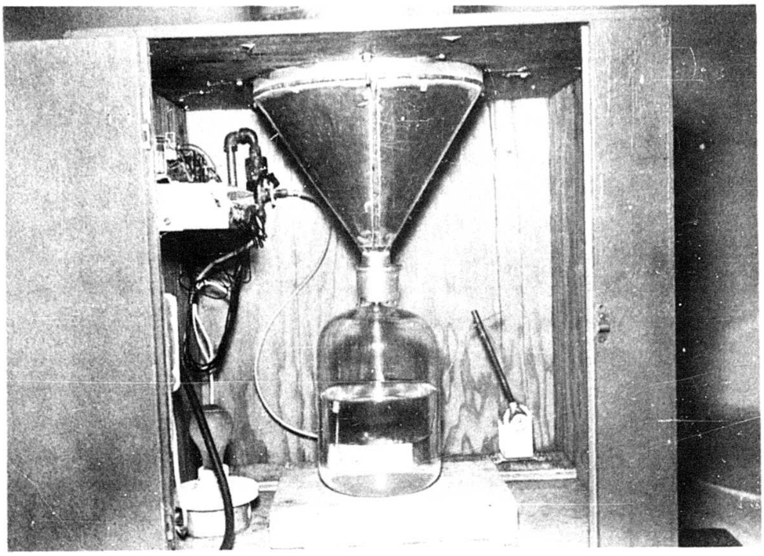
H2820

Fig. 7. Equipment used in analytical procedures.

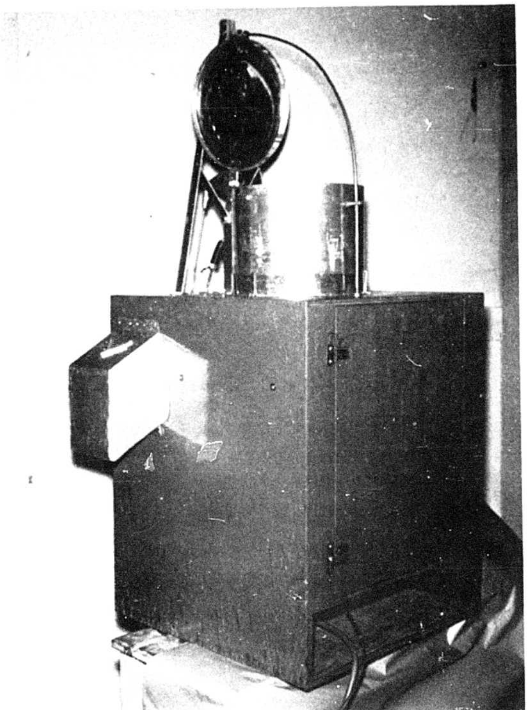


G11540

Fig. 8. Counting room, Sanitary Sciences Branch, showing equipment used for radioactivity measurements.

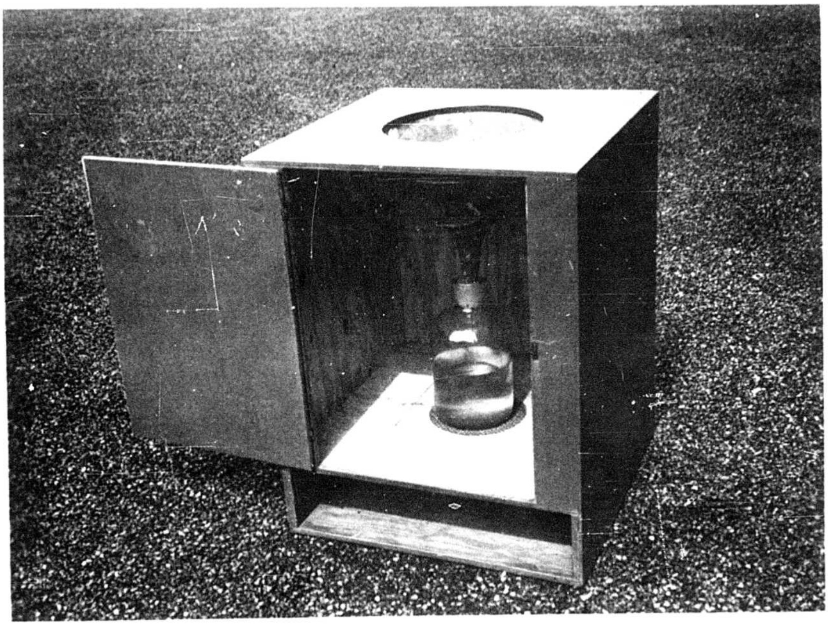


F6035



F5058

Fig. 9. Device for collecting rain and snow samples. Lower photograph shows open position which lid assumes when side-mounted sensing unit is wet. Upper view shows interior of box.



8908

Fig. 10. Device for collecting rain and snow samples, used prior to July 1959.

C11517

Fig. 11. Gummed paper station for collecting samples of radioactive fallout.

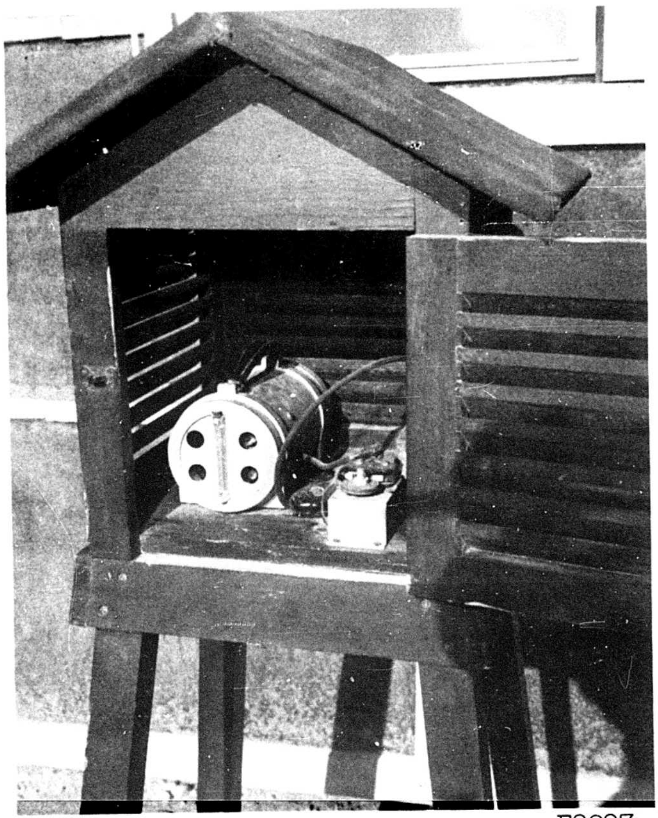
Radioactive dust or fallout from the atmosphere was collected on 1-square-foot sheets of gummed paper mounted on a frame (Fig. 11). After exposure, the paper was removed from the frame, compactly folded, placed into a fused silica dish, and carefully ashed in a muffle furnace slowly heated to a temperature range of 600° to 700° C. The ash was transferred quantitatively to a planchet and counted for gross beta activity.

Particulate radioactivity in the atmosphere has also been measured by means of an air filter unit which pumped 40 to 45 cubic feet of air per minute through a cellulose filter. The unit, housed in a louvered structure (Fig. 12), was operated on a timer for 15 minutes each hour in order to extend the life of the electric motor and to permit longer periods of operation between filter changes. The filters were removed after designated periods of operation ranging from 1 day to 1 week and were ashed in a muffle furnace. The residue was transferred to a planchet for counting. The results obtained were related to the volume of air filtered.

River bottom silt samples were collected (Fig. 13) by the use of a sampling device developed and fabricated by the Sanitary Sciences Branch. This device consists of a piece of $1\frac{1}{4}$-inch pipe about 5 inches long connected to one end of a piece of $\frac{1}{2}$-inch pipe about 8 feet long with a valve on the other end. The larger pipe was worked into the mud for about 5 inches with the valve open. The valve was closed to keep the mud from dropping out of the pipe while it was being raised to the surface. The sample was subsequently transferred to a beaker, dried at 110° C, and pulverized. A 1-gram portion placed in a planchet was counted for beta activity.

For the biota study, samples of adult fish were dissected and the parts desired for counting (scales, flesh, bone, and liver) were dried by pressing between adsorbent paper. A 1- to 3-gram portion of each part was weighed into a 50-milliliter beaker. One or two milliliters of concentrated HNO_3 were added and the sample was digested carefully to dryness under an infrared lamp. The beaker and the sample were placed in a muffle furnace and heated to a temperature range of 600° to 650° C for 5 to 10 minutes. The beaker was removed from the oven, cooled, and a 0.5-milliliter volume of concentrated HNO_3 was added. The sample was again evaporated to dryness and heated in the muffle furnace. When the sample was removed from the furnace and cooled, the residue was transferred to a stainless-steel planchet with concentrated HNO_3 and a little rinse water. The contents of the planchet were then evaporated to dryness under an infrared lamp and counted. Juvenile fish were cut into three sections. The center section, containing the viscera, was processed by the same procedure as that used for the parts of the adult fish. Algae samples were carefully washed to remove all foreign matter and dried by blotting with adsorbent paper. A 2-gram

E2922

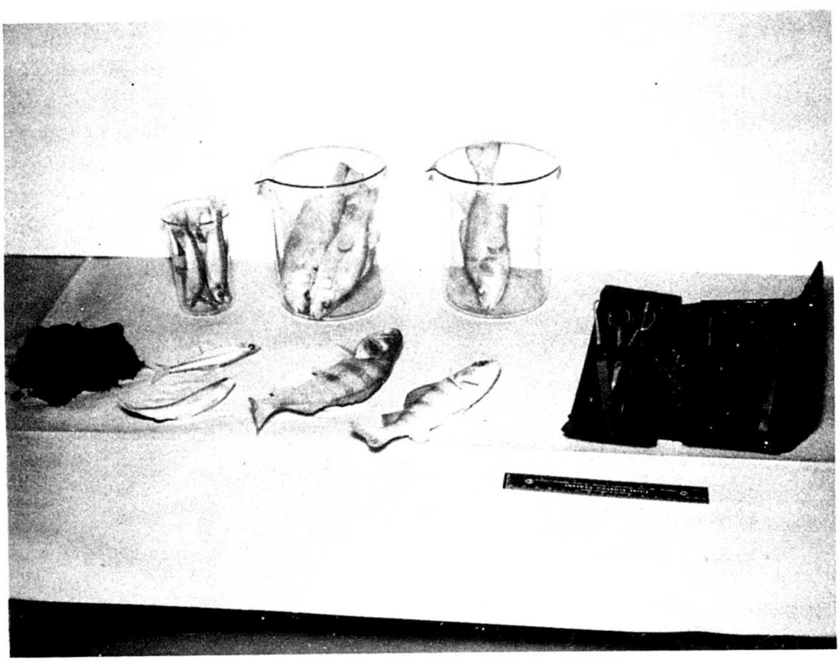


E2927

Fig. 12. Air filtration device used in collection of radio-active atmospheric particles. Upper picture shows cellulose filter pad removed from sampler.

H2816

Fig. 13. Taking bottom sediment sample from Potomac River at Whitestone Point.



H2821

Fig. 14. Samples of fish and algae used in biota study.

portion of each sample was weighed into a 50-milliliter beaker. Ten milliliters of concentrated HNO_3 were added and the sample boiled on a hotplate until the solution was yellow-brown in color. The solution was evaporated to near dryness and the boiling was repeated with 5 milliliters more of concentrated HNO_3. The solution was evaporated nearly to dryness. The digested sample was then transferred to a stainless-steel planchet with the aid of a rubber policeman and a little wash water, evaporated to dryness under an infrared lamp, and counted. Figure 14 shows some samples of fish and algae used in a biota study.

5. Results. The day-by-day results of the SM-1 monitoring program from its beginning in November 1955 to the end of 1960 have been submitted to the NPFO in quarterly progress reports. The composite results of these reports have been summarized and are presented in Tables II through XVII of this report.

Table II. Radioactivity in Water from Potomac River and Accotink Bay, 1954-1955

Month	Monthly Average of Gross Beta Radioactivity (10^{-8} μc/cc)			
	Potomac River		Accotink Bay	
	1954	1955	1954	1955
January	No determination	No determination	No determination	No determination
February	"	1.3	"	1.9
March	"	5.8	"	6.4
April	"	1.9	"	5.8
May	"	3.2	"	3.9
June	"	8.4	"	3.2
July	"	1.3	"	1.9
August	"	1.3	"	1.3
September	1.3	0.6	3.2	1.3
October	1.3	1.3	2.6	1.9
November	1.3	1.8	1.9	0.8
December	1.3	0.9	1.3	0.5
Average	1.3	2.5	2.2	2.6

Table III. Radioactivity in Water from Potomac River and Accotink Bay, 1956

Month	Monthly Average of Gross Beta Radioactivity (10^{-8} μc/cc)							
	Potomac River Locations							
	N. Gunston Cove	S. Gunston Cove	Glymont	Fort Washington	Whitestone Point	Dalecarlia Water Plant	Average of Six Stations	Accotink Bay
January	2.6	2.3	1.7	1.0	1.5	2.7	2.0	4.3
February	2.5	3.4	2.1	1.0	1.4	3.5	2.3	3.5
March	2.0	2.5	1.6	1.9	3.5	1.4	2.2	1.8
April	1.6	0.7	0.9	2.8	1.6	1.1	1.4	1.9
May	2.4	1.8	1.8	2.5	1.4	1.3	1.9	3.0
June	2.1	2.2	2.6	2.4	1.7	No determination	2.2	No determination
July	4.4	2.7	5.5	1.9	1.5	" "	3.2	" "
August	2.1	1.7	1.3	3.5	1.2	" "	2.0	" "
September	1.0	4.4	3.3	1.9	1.9	1.6	2.4	1.8
October	3.1	1.9	3.9	1.8	1.8	1.8	2.4	4.8
November	0.9	1.8	0.3	0.2	1.1	0.5	0.8	0.4
December	0.0	0.2	0.5	0.3	1.6	1.5	0.7	2.7
Average	2.1	2.1	2.1	1.8	1.7	1.7	2.0	2.7

Table IV. Radioactivity in Potomac River Water at Mackenzie Hall, 1959-1960

Month	Monthly Average of Gross Beta Radioactivity (10^{-8} μc/cc) 1959	1960
January	3.2	1.1
February	3.2	1.2
March	3.4	1.1
April	3.5	1.1
May	1.8	2.8
June	1.6	0.8
July	1.4	0.2
August	0.4	0.2
September	0.9	0.7
October	1.1	1.0
November	1.5	0.4
December	0.7	0.8
Average	1.9	1.0

Table V. Radioactivity in SM-1 Reactor Cooling Water, 1957-1960

Month	Monthly Average of Gross Beta Radioactivity (10^{-8} µc/cc)			
	1957		1958	
	Influent	Effluent	Influent	Effluent
January	No determination	No determination	3.2	5.1
February	"	"	0.9	1.4
March	"	"	2.3	1.6
April	"	"	1.6	1.7
May	1.4	0.5	1.3	0.8
June	1.4	2.4	2.1	2.2
July	4.0	2.7	1.8	1.0
August	2.0	1.6	2.3	2.6
September	3.2	4.4	1.6	1.9
October	2.4	2.8	1.0	0.7
November	2.6	2.7	2.2	2.6
December	1.8	1.4	1.7	3.2
Average	2.4	2.5	1.8	2.1
	1959		1960	
January	4.4	5.6	0.9	0.9
February	3.6	3.4	1.0	1.2
March	2.8	2.8	0.8	1.0
April	2.8	2.1	0.9	0.7
May	2.1	2.4	1.4	12.8
June	1.5	1.3	0.6	0.7
July	1.5	2.2	0.5	1.0
August	1.9	2.0	0.4	0.9
September	0.7	0.8	0.8	0.8
October	0.6	1.3	0.8	0.5
November	2.2	1.4	0.7	0.8
December	0.7	2.1	1.0	1.2
Average	1.9	2.2	0.8	1.9

Table VI. Gamma Radioactivity in SM-1 Reactor Cooling Water, 1959-1960

Month	Inlet Cs^{137}	Inlet K^{40}	Outlet Cs^{137}	Outlet K^{40}
	1959 — Monthly Average of Gamma Radioactivity (10^{-8} μc/cc)			
July	0	0	0.5	0
August	0.1	0.6	0	0
September	1.5	0	2.1	0
October	2.5	0.2	1.6	0
November	0	2.4	0	1.7
December	0.3	1.9	0	0.7
	1960			
January	No determination	No determination	No determination	No determination
February	1.4	0	1.9	0
March	1.3	1.1	1.7	3.7
April	No determination	No determination	No determination	No determination
May	21.7	0	105	0
June	0	1.6	0	4.6
July	0	0	5.6	2.5
August	No determination	No determination	No determination	No determination
September	0.1	0	0	0
October	0	0	0	0
November	0	0	0.5	0
December	No determination	No determination	No determination	No determination

Table VII. Radioactivity in USAERDL Well Water, 1955-1957

Month	Monthly Average of Gross Beta Radioactivity (10^{-8} μc/cc)		
	1955	1956	1957
January	No determination	2.9	0.7
February	" "	1.8	No determination
March	" "	1.4	" "
April	" "	0.4	" "
May	" "	0.5	" "
June	" "	0.9	" "
July	" "	0.2	" "
August	" "	3.2	" "
September	" "	2.5	" "
October	" "	2.3	" "
November	0.8	0.7	" "
December	0.7	0.7	" "
Average		1.5	

Table VIII. Fallout Radioactivity in the
Fort Belvoir-Washington, D. C. Area, 1955-1956

Month	Monthly Average of Gross Beta Radioactivity (millicuries/sq mile/month)								
	SM-1 Site	Davison Field	Gunston Manor	Mount Vernon	Fort Hunt	Marshall Hall	Dalecarlia Washington, D. C.	Masonic Memorial	Bldg 325 USAERDL
					1955				
November	35	25	128	107	89	53	7	9	34
December	23	26	24	36	17	30	6	4	30
Average	29	26	76	72	53	42	6	6	32
					1956				
January	43	41	36	46	37	49	67	41	71
February	35	44	37	34	34	31	40	30	38
March	71	61	66	50	68	52	53	47	50
April	55	58	64	55	59	43	50	24	58
May	47	8	59	56	49	148	68	67	32
June	10	7	5	10	8	30	36	5	10
July	67	80	61	67	50	331	325	43	67
August	18	30	23	19	19	92	82	16	19
September	222	304	246	336	254	232	295	192	220
October	57	49	49	72	64	60	67	31	55
November	31	32	32	35	40	30	32	13	36
December	42	54	32	26	40	74	35	19	31
Average	58	64	59	67	60	98	96	44	57

Table IX. Fallout Radioactivity in the Fort Belvoir-Washington, D. C. Area, 1957

Month	Monthly Average of Gross Beta Radioactivity (millicuries/sq mile/month)				
	SM-1 Site	White-stone Point	Davison Field	Dalecarlia Washington, D. C.	Bldg 325 USAERDL
January	28	20	40	66	29
February	43	41	54	58	43
March	91	91	94	134	101
April	194	377	71	238	413
May	43	62	62	No determination	52
June	350	389	550	" "	373
July	576	657	460	" "	612
August	120	134	142	" "	114
September	1370	1490	1940	" "	1380
October	113	116	102	" "	113
November	37	41	47	" "	41
December	47	50	54	" "	60
Average	251	288	301	128	278

Table X. Fallout Radioactivity in the Fort Belvoir Area, 1958

Month	Monthly Average of Gross Beta Radioactivity (millicuries/sq mile/month)			
	SM-1 Site	Whitestone Point	Davison Field	Bldg 325 USAERDL
January	84	122	151	80
February	34	39	36	37
March	312	204	251	202
April	146	186	236	262
May	114	124	132	83
June	139	169	143	137
July	221	263	316	259
August	118	116	144	143
September	35	42	42	61
October	128	No determination	212	No determination
November	266	" "	336	" "
December	162	" "	185	" "
Average	147	141	182	140

Table XI. Fallout Radioactivity in the Fort Belvoir Area, 1959-1960

Month	Monthly Average of Gross Beta Radioactivity (millicuries/sq mile/month)			
	SM-1 Site		Davison Field	
	1959	1960	1959	1960
January	167	5	165	10
February	115	4	169	56
March	137	7	169	8
April	222	12	238	17
May	80	11	106	17
June	60	4	80	8
July	25	1	44	6
August	7	2	11	5
September	6	4	7	6
October	10	2	10	4
November	5	2	6	5
December	5	2	8	2
Average	70	5	84	12

Table XII. Radioactivity in Rain or Snow in the Fort Belvoir Area, 1954-1960

Month	Monthly Average of Gross Beta Radioactivity (10^{-8} μc/cc)						
	1954	1955	1956	1957	1958	1959	1960
January	No determination	No determination	60	40	25	170	2
February	"	19	24	9	15	188	4
March	"	346	40	67	55	183	5
April	"	3430	61	312	39	No determination	2
May	"	572	68	55	40	75	3
June	"	35	32	149	32	12	No determination
July	7	6	71	12	33	23	2
August	8	2	92	47	41	No determination	1
September	16	9	99	185	20	6	1
October	5	2	29	58	19	8	2
November	45	No determination	10	11	52	7	2
December	61	"	116	10	15	5	1
Average	24	491	58	80	32	68	2

Table XIII. Radioactivity of Atmospheric Particles at Two Fort Belvoir Air Filtration Stations, 1956-1958

Month	Monthly Average of Gross Beta Particulate Activity of Filtered Air (micromicrocuries/1000 cu ft)					
	SM-1 Site			North Post		
	1956	1957	1958	1956	1957	1958
January	No determination	No determination	32	No determination	No determination	No determination
February	"	"	40	14	"	27
March	47	"	91	33	"	82
April	42	"	210	22	"	190
May	63	"	160	54	"	150
June	42	"	130	53	"	97
July	31	"	110	15	"	93
August	32	"	97	27	"	98
September	45	44	44	75	53	41
October	31	56	No determination	27	72	No determination
November	14	37	"	No determination	33	"
December	21	22	"	"	48	"
Average	37	40	102	36	52	97

Table XIV. Radioactivity of Potomac River Bottom Sediment, 1955-1960

Month	Monthly Average of Gross Beta Radioactivity (micromicrocuries/gm)																					
	Main Stream		Gunston Cove		SM-1 Outlet				Mackenzie Hall		Whitestone Point				Hallowing Point				Glymont			
	1955	1956	1955	1956	1957	1958	1959	1960	1958	1959	1957	1958	1959	1960	1957	1958	1959	1960	1957	1958	1959	1960
January						40	11															
February					45	40	15	17		25			2					29			5	20
March		29		32		29	5			26												
April					8	28	12			12	6				0				0			
May					21	19	25			15			19				11				3	
June		48		36	15		12	17		18				13				12				14
July					29	43	25			19	0	0			59	8			24	8		
August					19	3																
September					8	21																
October		31		32	20	12		20	4		43	13		12	43	5		17	43	8		18
November	11		19		14	33			36													
December					15	19			11				41				11				23	
Average	11	36	19	33	19	26	15	18	17	19	24	6	21	12	34	6	9	19	22	8	10	17

NOTE: Blank spaces indicate no determinations were made.

Table XV. Radioactivity in Adult Fish, 1957-1960

Month	Species	Scales	Skin	Flesh	Bone	G. I. Tract	Stomach	Liver	Average of All Parts
		Average Gross Beta Radioactivity (micromicrocuries/gm)							
		1957							
October	White Perch	4	4	4	0	0	16	20	7
	Yellow Perch	0	0	20	24	32	60	72	30
	Catfish	No determination	24	8	8	8	80	0	21
	Eel	0	8	8	0	8	No determination	8	5
		1958							
November	Smallmouth Bass	0	0	0	8	0	0	0	1
	Largemouth Bass	0	0	8	0	0	0	0	1
	Catfish	No determination	0	8	0	0	0	0	1
December	Crappie	8	24	8	0	0	0	0	6
	Bluegill	0	8	0	4	0	4	0	2
	Yellow Perch	0	8	8	0	0	0	0	2
	White Perch	16	0	24	0	0	8	0	7
	Roach	8	8	0	0	0	0	0	2
	Sunfish	24	8	8	0	0	8	8	8
		1959							
June	Herring	16	24	16	16	0	8	32	16
	Yellow Perch	24	24	24	40	97	64	0	39
	Catfish	No determination	8	0	0	8	0	No determination	3
	Bluegill	8	0	0	16	32	0	0	8
	Smallmouth Bass	0	0	0	0	0	0	16	2
September	Sunfish	0	0	5	0	5	5	0	2
	Catfish	No determination	0	5	5	5	5	4	4
	White Perch	0	5	9	9	0	5	9	5
	Yellow Perch	0	9	0	9	9	0	0	4
	Eel	No determination	0	0	0	0	0	0	0
		1960							
February	Catfish	0	0	3	5	12	9	0	4
	Carp	6	3	1	10	6	6	4	5
June	White Perch	11	2	8	13	13	5	13	9
	Catfish	No determination	3	3	7	3	3	3	4
	Sunfish	5	4	0	9	7	3	5	5
September	Silver Perch	3	0	0	0	0	0	5	1
	Sunfish	4	9	3	5	6	10	12	7
	Catfish	0	0	0	0	0	0	0	0

Table XVI. Radioactivity in Juvenile Fish Taken from Gunston Cove, 1959-1960

Month	Average Gross Beta Radioactivity (micromicrocuries/gm)	
	1959	1960
February	No determination	5
June	8	3
August	No determination	3
September	5	No determination

Table XVII. Radioactivity in Filamentous Algae, 1957-1960

Month	Average Gross Beta Radioactivity (micromicrocuries/gm)		
	Mackenzie Hall	SM-1 Outlet Channel	Gunston Cove
		1957	
October	No determination	No determination	52
		1958	
November	No determination	No determination	70
		1959	
June	No determination	No determination	107
September	17	No determination	29
		1960	
February	21	422	No determination
April	14	183	" "
June	No determination	87	" "
August	9	136	" "

III. DISCUSSION

6. Water. Prior to the installation of the SM-1 reactor at Fort Belvoir, during the sampling period of September 1954 to the end of 1956, the normal radioactivity level for all samples of water taken from the Potomac River and Accotink Bay averaged 2.2×10^{-8} μc/cc. Subsequent to the reactor startup in April 1957, the average values for all samples of the Potomac River taken at Mackenzie Hall and at the SM-1 cooling water intake averaged 1.6×10^{-8} μc/cc. Samples of condenser cooling water discharged to Accotink Bay during the period from plant startup time to the end of 1960 averaged 2.2×10^{-8} μc/cc. These values indicate that the operation of the SM-1 plant has not changed the normal background radioactivity in the Potomac River. Figure 15 shows the monthly averages of radioactivity in the Potomac River for 1954 through 1960. Figure 16 shows the monthly averages of radioactivity in the SM-1 condenser cooling water influent and effluent from the start of sampling in May 1957 to the end of 1960.

The highest activity value of Potomac River water, recorded on 19 April 1955, almost 2 years before the SM-1 reactor startup, was 3.4×10^{-7} μc/cc. A rainwater sample collected on the same date was recorded at 2.5×10^{-4} μc/cc. Information supplied by the Atomic Energy Commission and the U. S. Weather Bureau showed that these high values were directly related to nuclear bomb tests at the Nevada Test Site on 6, 9, and 15 April. The highest values for liquid discharged from the SM-1 plant were 4×10^{-7} μc/cc and 16×10^{-7} μc/cc recorded on 11 and 13 May 1960. The latter sample was taken during a shutdown of the reactor plant, with no condenser water flowing. The estimated flow at the outfall was 5 gpm for this sample. The highest value of gamma activity in the reactor condenser cooling water (Cs^{137} = 1.0×10^{-6} μc/cc) was recorded during May 1960 (Table VI).

7. Fallout on Gummed Paper. Figure 17 indicates that fallout values have fluctuated widely. From November 1955, when a regular sampling schedule was initiated, to the end of December 1960, the highest monthly average of fallout activity in the Fort Belvoir area was recorded as 1,940 millicuries/sq mile/month at Davison Field for September 1957. The value for December 1960 at the same station was 2 millicuries/sq mile/month. Prior to November 1955, the highest fallout value for a single day exposure of gummed paper was recorded on 18 April 1955 as 1,100 millicuries/sq mile/day (33,000 millicuries/sq mile/month). This heavy fallout was associated with a 0.02-inch rainfall the activity of which measured 2.5×10^{-4} μc/cc and was attributable to the same schedule of nuclear bomb testing in Nevada as noted under par. 6, "Water."

Significant fluctuations in the fallout activity can be directly related to the detonation of nuclear devices around the

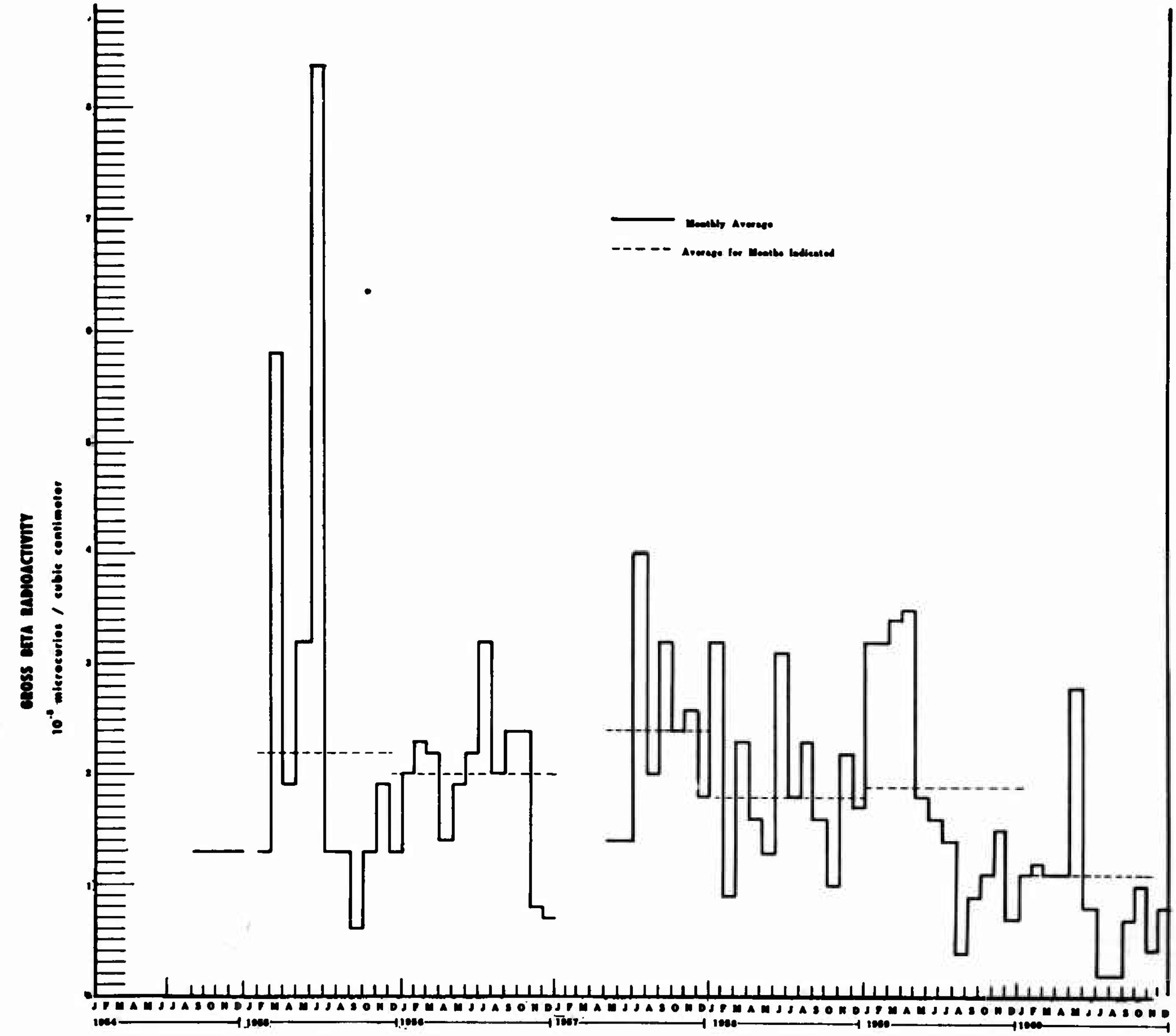


Fig. 15. Radioactivity in Potomac River water.

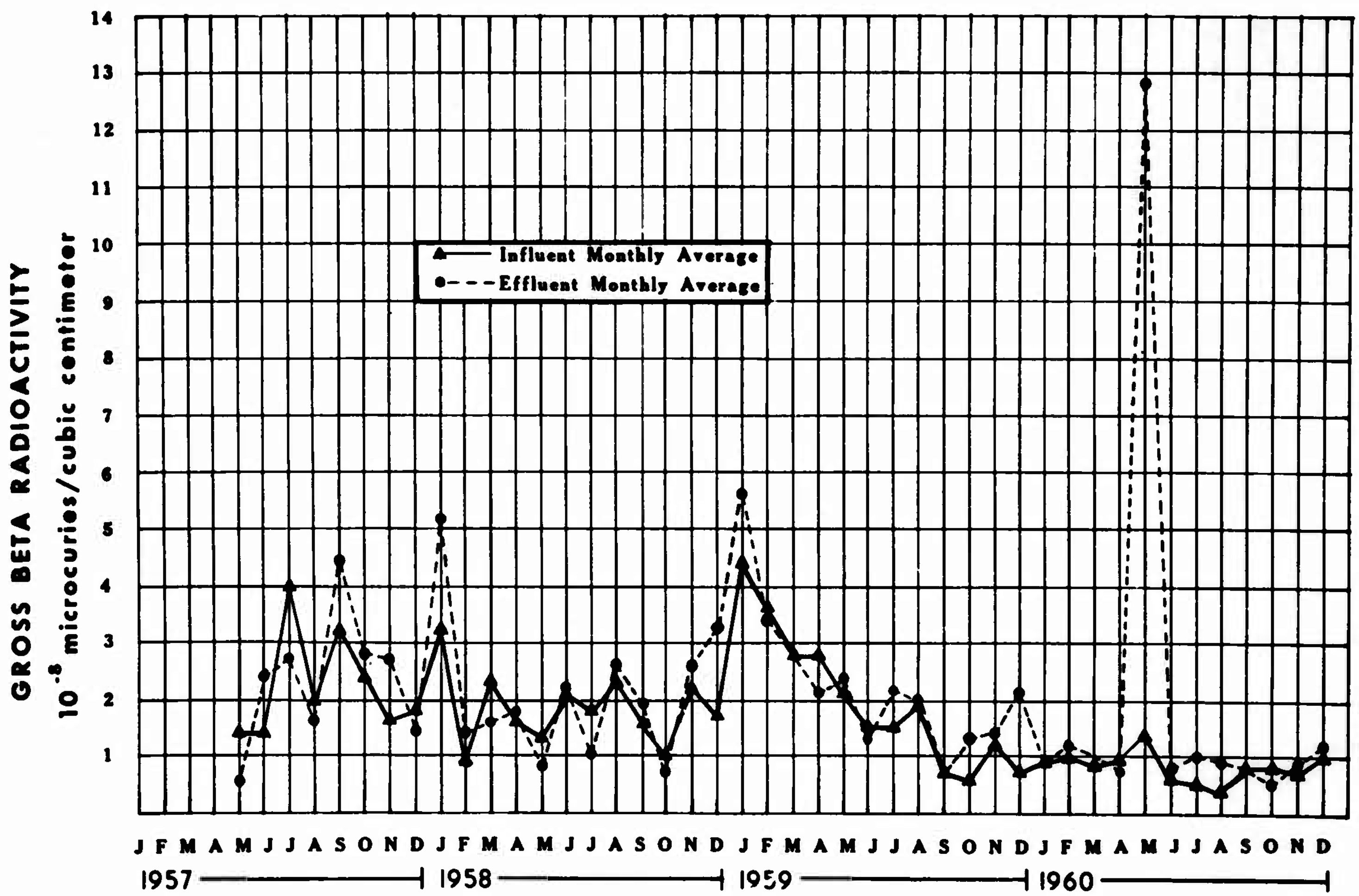


Fig. 16. Radioactivity in SM-1 condenser cooling water influent and effluent.

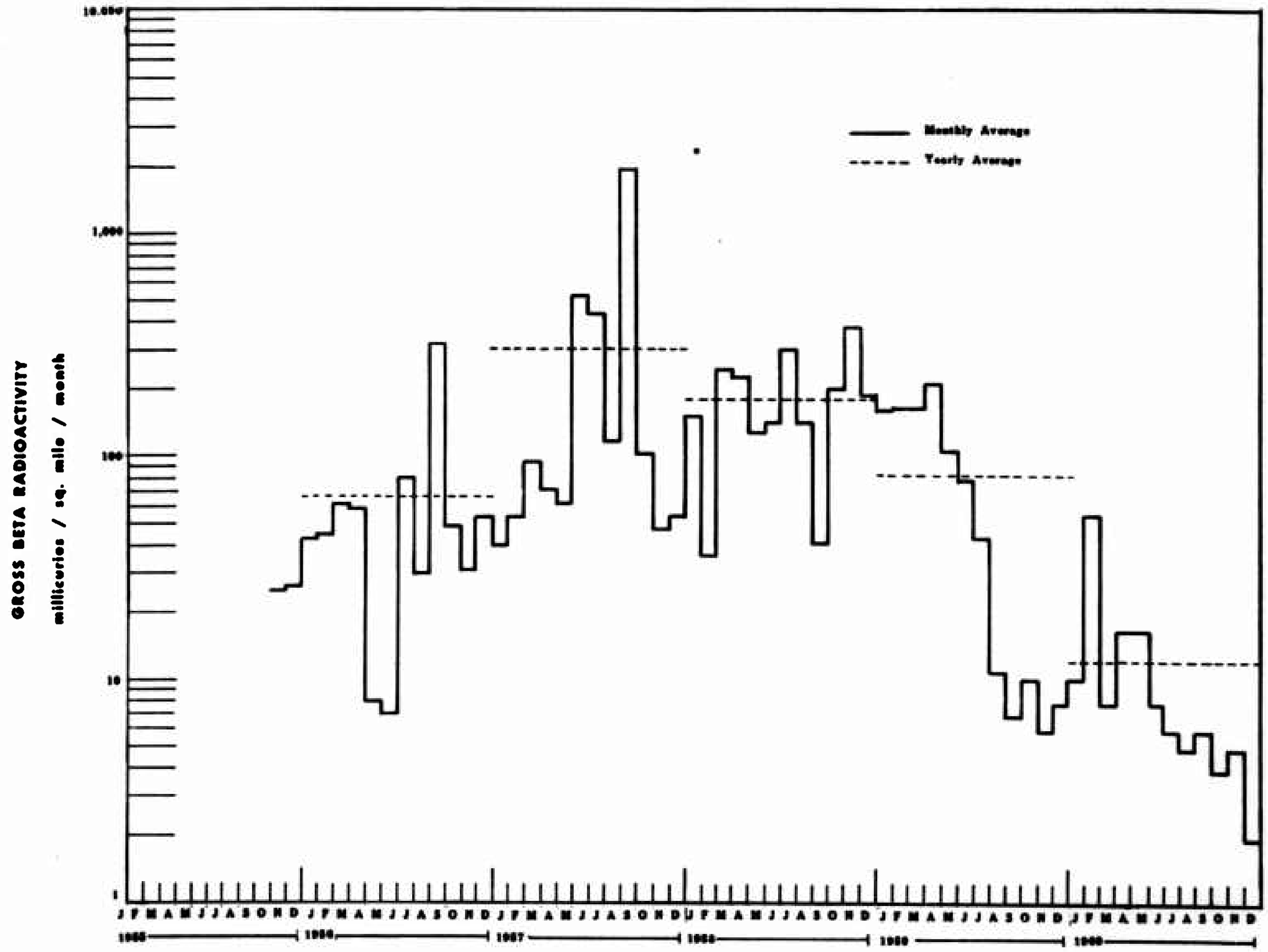


Fig. 17. Radioactivity of fallout at Davison Field gummed paper station.

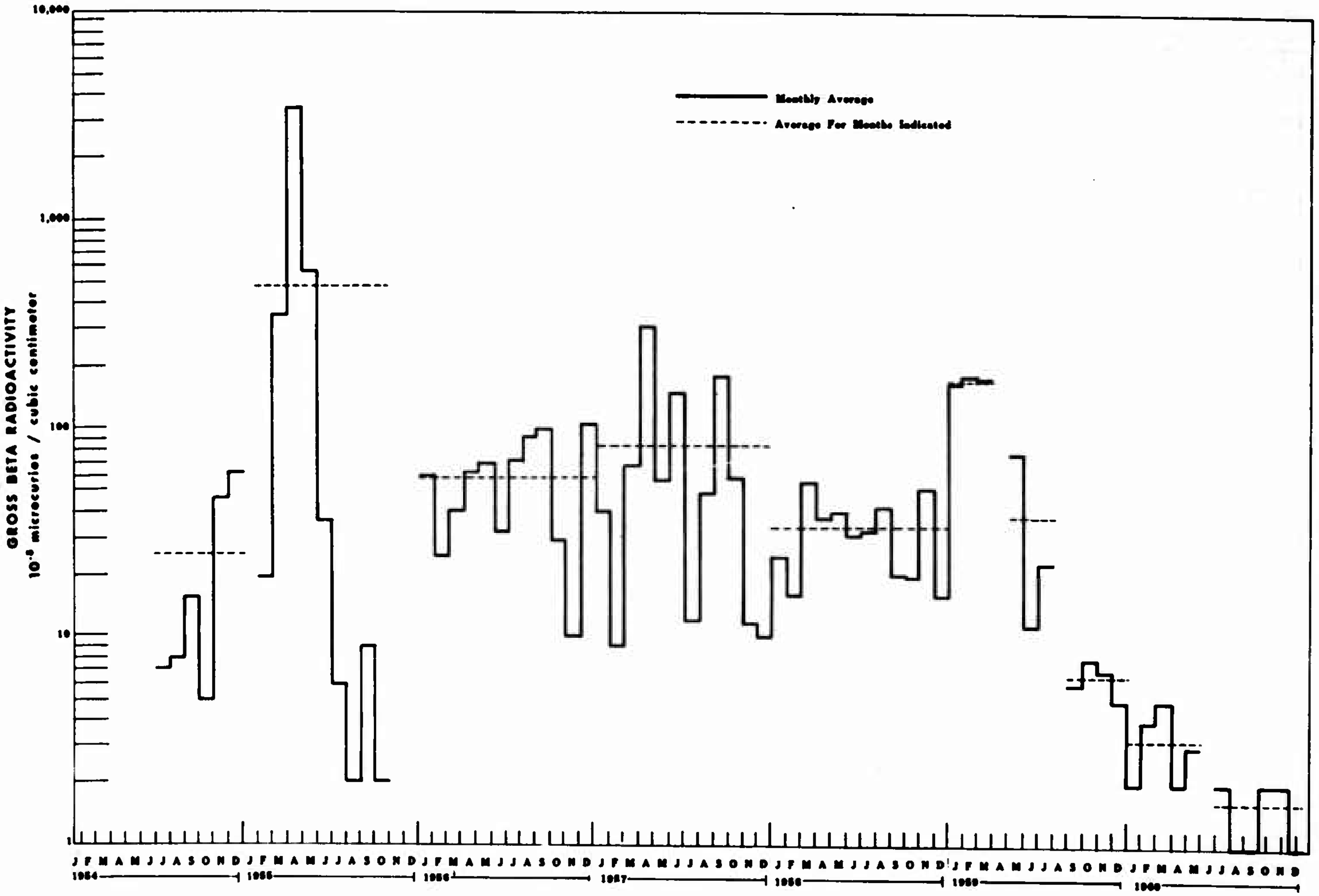


Fig. 18. Radioactivity in rain and snow, sampled on roof of Bldg. 325, USAERDL.

world as reported by the Atomic Energy Commission. During periods of frequent nuclear weapons testing by the world powers, increased fallout activity was noted. As the frequency of testing lessened, or when nuclear weapons testing stopped completely, as after October 1958, a trend to decidedly lower fallout levels was observed. Table XI shows this markedly. The effect of the French nuclear detonation of 13 February 1960 on the fallout average for February 1960 should be noted. The steady decline of fallout activity in the Fort Belvoir area since the cessation of nuclear weapons testing together with the continuous operation of the SM-1 plant suggest that the fallout activity is in no way related to the reactor operation.

8. Atmospheric Radioactivity. The facts which have just been stated relating to the activity of fallout on gummed paper and the weapons testing program apply to the results obtained by air filtration and the measurement of rain and snow samples. Figure 18 shows that the activity of rain and snow has steadily decreased following the cessation of nuclear device testing at the end of October 1958.

9. Potomac River Bottom Sediment. A check of the data relating to the activity of Potomac River bottom sediment indicates a low level of activity. Average values range from a low of 6 micromicrocuries per gram for samples taken during 1958 to a high of 36 for 1956.

10. Biota. Data obtained during the biota study initiated in October 1957 relating to adult and juvenile fish show for all specimens a low level of activity, ranging from 0 to 39 micromicrocuries per gram (Table XV). Up to September 1959, samples of filamentous algae were taken in Gunston Cove and the average value for all samples taken in that area was 56 micromicrocuries per gram. In 1960, the algae sampling locations were changed to Mackenzie Hall and the channel leading from the SM-1 condenser cooling water outfall to Gunston Cove. The average activity value for 1960 for algae samples taken at Mackenzie Hall was 15 micromicrocuries per gram. For the same period, samples taken in the SM-1 outlet channel showed an average value of 207 micromicrocuries per gram. The highest value for a single algae sample taken at this location was 1,240 micromicrocuries per gram. The highest monthly average recorded was 422 micromicrocuries per gram, for ten samples taken during February 1960. The fact that activity values for those samples of algae taken from the outlet channel are more than ten times greater than the values for samples taken from the Mackenzie Hall location, upstream from the reactor, indicates some concentration by algae of activity from the SM-1 condenser cooling water. (Table XVII.)

IV. CONCLUSION

11. Conclusion. It is concluded that after more than 3 years of SM-1 reactor operation, no significant increase has been noted in the radiological background level in the Fort Belvoir area.

Special Category

DISTRIBUTION FOR USAERDL REPORT 1691-TR

TITLE The SM-1 Environmental Radiological Monitoring Program November 1954 - December 1960

DATE OF REPORT 31 August 1961 CLASSIFICATION U

ADDRESSEE	REPORT	ABSTRACT
Department of Defense		
Technical Library Office, Asst Secretary of Defense Washington 25, D. C.	1	1
Department of the Army		
Chemical Corps		
U. S. Army Chemical Warfare Laboratories Technical Library Army Chemical Center, Maryland	1	-
Chemical Corps Research and Development Command Biological Warfare Laboratories Fort Detrick Frederick, Maryland Attn: Director of Facilities and Services	1	1
Corps of Engineers		
Engineer Research and Development Division Office, Chief of Engineers Department of the Army Room 1406 Washington 25, D. C.	4	-
Chief of Engineers Department of the Army Washington 25, D. C. Attn: ENGRD-P	1	-
District Engineer St. Louis District, Corps of Engineers 420 Locust Street St. Louis, 2, Missouri Attn: IMLOL	2	2
OCE Liaison Officer U. S. Army Combat Development Experimentation Center Fort Ord, California	1	-

ADDRESSEE	REPORT	ABSTRACT
Corps of Engineers (cont'd)		
Engineer Historical Division, OCE P O Box 1715 Baltimore 3, Maryland	-	2
Commanding General Army Map Service 6500 Brooks Lane Washington 25, D. C. Attn: Documents Library	2	-
The Engineer School Library Building 270 Fort Belvoir, Virginia	1	-
Director, Department of Training Publications U. S. Army Engineer School Fort Belvoir, Virginia Attn: O&A	1	-
USAERDL Liaison Officer U. S. Army Engineer Maintenance Center 52 Starling Street Columbus, Ohio	3	-
Commanding Officer U. S. Army Polar R&D Center Fort Belvoir, Virginia Attn: Arctic Library	1	-
USAERDL Liaison Officer U. S. Army Ordnance Mission White Sands Missile Range White Sands, New Mexico	1	-
USAERDL Liaison Officer U. S. Army Signal R&D Laboratory Fort Monmouth, New Jersey	1	-
Technical Director GIMRADA Fort Belvoir, Virginia	1	-
USAERDL		
Director	1	-
Military Department	1	-
Sanitary Sciences Branch	25	-

ADDRESSEE	REPORT	ABSTRACT
<u>USAERDL</u> (cont'd)		
R&D Project Case File	1	-
Technical Documents Center	2	-
Office of Counsel	1	-
Reports Section	3	-
Civ, Mech, Elec, Mil, Engr, and TS Depts (circulate)	1	-
British Liaison Officer	5	4
Canadian Liaison Officer	5	-
Transportation Corps Liaison Officer	2	-
USCONARC Liaison Officer	1	-
<u>Ordnance Corps</u>		
Commanding General Frankford Arsenal Pitman-Dunn Laboratory Group Philadelphia 37, Pennsylvania Attn: Library	1	-
<u>Overseas Commands</u>		
Office of the Engineer AFFE/8A (REAR) APO 343 San Francisco, California	1	1
The Engineer Headquarters, USAREUR APO 403 New York, N. Y. Attn: I&M Branch	3	-
Engineer Section USARCARIB Fort Amador, Canal Zone	1	-
Engineer Headquarters 7th Army APO 46 New York, N. Y.	1	-

ADDRESSEE	REPORT	ABSTRACT
Overseas Commands (cont'd)		
Chief Engineer Support Control Office USAREUR Support Control Center APO 58 New York, N. Y. Attn: Chief, Cat. Branch, GED	2	-
Senior Standardization Representative U. S. Army Standardization Group, UK USN 100, FPO Box 65 New York, N. Y.	1	-
Quartermaster Corps		
Commander Hq, Quartermaster Research and Development Command Quartermaster Research and Development Center Natick, Massachusetts Attn: Technical Library	2	-
Commander Quartermaster Field Evaluation Agency Quartermaster Research and Engineering Command Fort Lee, Virginia	1	-
Transportation Corps		
Chief of Transportation Washington 25, D. C. Attn: TCACR-TC	1	-
USCONARC		
Commanding General Continental Army Command Fort Monroe, Virginia Attn: Engineer Section	2	-
Chairman Engineer Committee Tactical Department, Technical Information Service Fort Benning, Georgia	1	1
Combat Developments Office U. S. Army Infantry School Fort Benning, Georgia Attn: Engineer Advisor	1	-

ADDRESSEE	REPORT	ABSTRACT
<u>USCONARC</u> (cont'd)		
President U. S. Army Armor Board Fort Knox, Kentucky Attn: Chief, Engineer Section	-	1
<u>Department of the Navy</u>		
Chief, Bureau of Yards and Docks Department of the Navy Washington 25, D. C. Attn: Code D-400	1	-
Officer in Charge (Code 200C8) U. S. Naval Civil Engineering Research and Evaluation Laboratory Port Hueneme, California	1	-
Chief, Bureau of Ships Research and Development Program Planning Branch (Code 320) Washington 25, D. C.	3	3
Chief of Naval Research Reports Branch (Code 530) Department of the Navy Washington 25, D. C.	1	-
Commandant of Marine Corps (Code AO4E) Headquarters Marine Corps Washington 25, D. C.	1	-
Commanding Officer U. S. Naval Construction Battalion Center Port Hueneme, California	-	1
Director, Marine Corps Development Center Marine Corps Landing Force Development Center Marine Corps Schools Quantico, Virginia	1	-
<u>Department of the Air Force</u>		
Headquarters, U. S. Air Force (AFDRT-ER) Washington 25, D. C.	1	-
Headquarters, U. S. Air Force (AFOCE-T) Building T-8 Washington 25, D. C.	2	-

ADDRESSEE	REPORT	ABSTRACT
Department of the Air Force (cont'd)		
Air Force Special Weapons Center (SWRB) Kirtland Air Force Base, New Mexico	1	-
Strategic Air Command (DECE) Offutt Air Force Base, Nebraska	2	2
Continental Air Command (CNECE) Mitchel Air Force Base, New York	1	1
Aeronautical Chart and Information Center (ACDEL-7) Second and Arsenal Streets St. Louis 18, Missouri	1	1
Air Force Ballistic Missile Division (WDSOT) Air Force Unit Post Office Los Angeles 45, California	1	1
Washington ARDC Regional Office c/o Department of the Navy Room 4549, Munitions Building Washington 25, D. C.	1	-
Other Government Agencies		
Commandant (ETD) U. S. Coast Guard Headquarters 1300 E Street, NW Washington 25, D. C.	-	2
Commanding Officer Field Testing and Development Unit U. S. Coast Guard Yard Curtis Bay 26, Maryland	-	1

UNCLASSIFIED

UNCLASSIFIED